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For decades the track record for the Soviet Union's program of unmanned exploration of the planet Mars has been less than impressive. Several early spacecraft never reached an Earth parking orbit. Three others are known to have never made it beyond Earth orbit. Three more probes failed enroute to Mars. One craft failed in its attempt to orbit the Red Planet. Three orbiters, while successful in accomplishing their main tasks, returned less information than hoped. Four landing attempts either crashed, missed the planet entirely, or ceased functioning soon after touchdown. Most recently, PHOBOS 2 failed before it was able to complete its rendezvous mission with the Martian moon Phobos.

The Soviets have proven that they are capable of better things in the field of planetary exploration, however. Ten unmanned probes have successfully landed on the hellish world of Venus. Four other spacecraft were placed into orbit around the cloud-shrouded planet. Two of these orbiters made high-resolution radar maps of Venus' northern hemisphere. Their data on the planet's surface will not be surpassed until the United States' MAGELLAN spacecraft goes into Venusian orbit in August of 1990. Two more Soviet probes placed balloons in the Venusian atmosphere, while the main buses of these spacecraft flew on to study Comet Halley. After their impressive string of accomplishments with the VENERA and VEGA programs, the Soviets felt they had the technology, confidence, and international savvy to attempt their first new missions to Mars since 1974.

Starting in the early 1980s, the Soviets slowly developed a ambitious program to explore the Red Planet. A totally new, modular spacecraft bus was designed to replace the twenty-year-old second generation planetary bus that the Soviets used in their VENERA program. The two PHOBOS spacecraft launched in the summer of 1988 towards Mars were the first phase in the Soviet's new Mars initiative, becoming the first to make use of this new spacecraft design. Unfortunately, they were also the first to uncover a number of its design deficiencies - the result of hurried planning and lack of communication between the spacecraft manufacturer and the mission scientists.

The Soviets have already stated that the next missions to use this third generation planetary bus will have upgraded computers, an omnidirectional antenna for receiving emergency commands, an autonomous attitude recovery capability, and improved backup batteries installed. These improvements, along with much better overall mission planning, should prevent the failures experienced by the PHOBOS 1 and 2 spacecraft.

In late 1989, the Soviet government approved a three hundred

million ruble (about 450 million dollar) program called MARS 1994. The goal of the MARS 1994 mission is to place two spacecraft in orbit around Mars which will deploy landers and balloons to make direct measurements of the Martian surface. The orbiters will employ their own instruments to make remote observations from space. Like the VEGA and PHOBOS missions, the Soviets intend to make this a cooperative scientific program which will involve France, many Eastern European nations, and the United States. While most of the spacecraft's instruments and many of the mission details remain to be determined, a fairly clear picture of the MARS 1994 mission is emerging, thanks in part to the new "openess" of the Soviets.

In September of 1994, two six metric ton (13,000-pound) spacecraft based on the PHOBOS design will be sent into space on separate PROTON launch vehicles. The two spacecraft will enter highly elliptical polar orbits around Mars after an interplanetary voyage of slightly less than one year. After attaining an initial orbit, the vehicles will settle into an orbit with an inclination of about one hundred degrees and a period of twelve hours. Their orbits will range from a high point of twenty thousand kilometers (12,000 miles) to a low point of two hundred to five hundred kilometers (120 to 300 miles) above the Martian surface. While in orbit, the spacecraft will continue observations begun six years earlier by PHOBOS 2. About two hundred kilograms (440 pounds) of instruments will be carried, including an imaging system with a maximum resolution of about one meter (39.37 inches) and a collection of other instruments to remotely probe the Martian surface properties and composition, observe the atmosphere, and make various measurements of the elusive Martian magnetic field.

Some time after the spacecraft have entered orbit around Mars, each will deploy a package towards the surface. Each package will likely contain four spike-like penetrators and a highly novel balloon. The landing sites have not been chosen yet, but the selection would be based on data obtained by the VIKING orbiters, PHOBOS 2, and the MARS OBSERVER (currently scheduled to be launched by the United States in 1992), as well as the MARS 1994 orbiters themselves. It is expected that the landing sites will be much more interesting than the VIKING landing sites. Those sites were chosen in 1976 because they were considered to be "safe" for making a "blind" landing. Unfortunately, "safe" also means "dull". Areas that included interesting features such as volcanoes, channels cut by water, canyons, and other exotic terrains are much rougher. The VIKING landers would have most likely been destroyed during a landing attempt in one of the places. Penetrators, on the other hand, are very rugged and balloons can fly over most obstacles. These inherent advantages should open up a much wider range of potential landing sites that are far more interesting than the two examined to date.

The design and capabilities of the penetrators has yet to be finalized. Each will weigh a few tens of kilograms and be capable of burying themselves into solid rock. The only experiment selected so far has been a seismometer for transmitting information about Mars' surface movements for some as yet undefined period of time. It is also likely that simple meteorological measurements such as temperature

and pressure will be made. The penetrator design should be announced sometime in 1990.

At this time the balloon package is much better defined and numerous tests have already been conducted with it. The balloon package will consist of a twenty-meter (66-foot) tall balloon supplied by the French CNES (Centre National d'Etudes Spatiales, the National Center for Space Studies), with a four-kilogram (nine-pound) panoramic camera package hanging below and a four-kilogram (nine-pound) instrument-laden "snake" supplied by The Planetary Society dangling at its base. The balloon will be divided into two parts: A helium filled upper portion and a lower portion filled with the ambient Martian atmosphere. At night the balloon will have enough buoyancy to hold itself and the camera package above the Martian surface while the "snake" lies on the ground. In this way, the camera package can make images of the ground below with a resolution of less than one millimeter (0.04 inch), while the instruments in the "snake" make measurements of the composition and physical properties of the nearby soil and rocks.

In the morning, the balloon will absorb the Sun's rays and heat the cool Martian air inside its lower portion. The air will begin to expand, whereafter the balloon will generate enough additional buoyancy to lift the "snake" off the ground. The balloon will then rise at a speed of about one meter per second (39.37 inches per second) to an altitude of two to four kilometers (1.2 to 2.4 miles), where it will ride on the Martian winds. The camera package will be relaying images of the planet's surface to the Soviet MARS orbiters and to a specially installed receiver on the American MARS OBSERVER, which should still be functioning after two years in orbit. It may also be possible to use Earth-based radio telescopes to track the balloons, as was done with the balloons deployed in the dense Venusian atmosphere by the VEGA spacecraft in 1985. Using VLBI (Very Long Baseline Interferometry) techniques, it should be possible to determine the balloons' locations and clock the wind speeds in various parts of the Martian atmosphere.

Once the Sun "sets", the air inside the balloon will cool, causing the balloon to slowly sink to the ground. Once the "snake" comes in contact with the surface, the balloon will drop no further and the "snake" will be able to make more surface measurements in yet another location. When the Sun "rises" the next morning, the balloon will heat up and the process will repeat. Using this novel method for locomotion, the balloon can travel a few hundred kilometers a day, studying widely separated locations and obtaining numerous high resolution images that will complement the orbiters' images. According to current estimates, each balloon should be capable of ten such cycles and cover a few thousand kilometers before too much helium leaks from the balloon, making it impossible to hold itself off the ground at night.

If this mission proves successful, it should vastly increase our knowledge about the planet Mars. The penetrators scattered over eight sites should give new information on the level of geological activity

on Mars and indications of the planet's internal structure. The two balloons should give us data on the composition of as many as twenty widely scattered sites, return highly detailed swaths of images of the Martian surface several thousand kilometers long, and yield much information on the Martian winds.

If the quality of the data returned by the Mars orbiters is comparable to that briefly returned by PHOBOS 2, the amount of data we may receive and what it tells us could be staggering. When combined with the data returned by the penetrators and balloons, scientists should have a much better understanding of Mars' surface properties and composition on a global scale, a better picture of the atmosphere and its motions, and a much more detailed knowledge of the Martian water inventory. All this information should give scientists and engineers an excellent foundation to plan future missions to the Red Planet, including soil sample return missions and manned expeditions. If the Soviets can overcome their legacy of Mars mission failures, the MARS 1994 mission stands to make a key contribution to our understanding of the Red Planet in the closing years of this century.

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